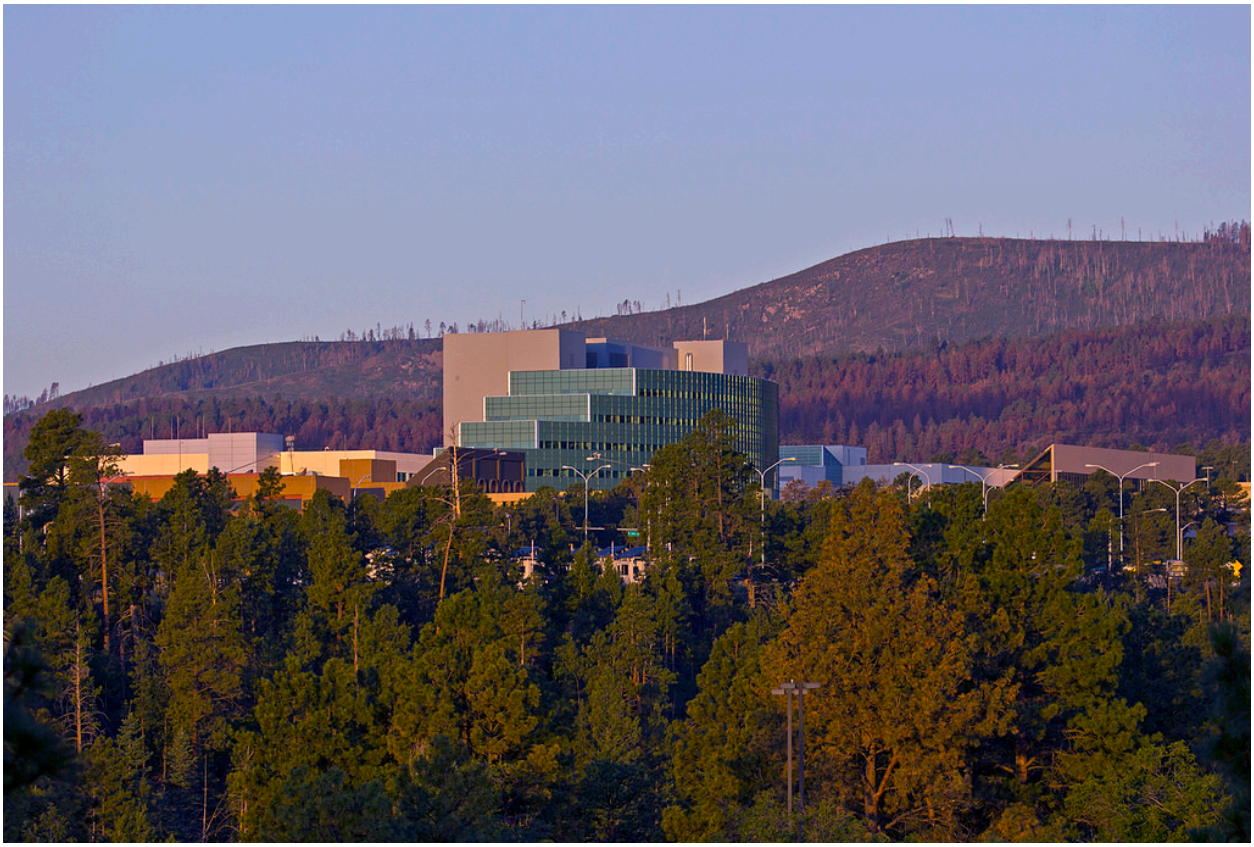
# Ancient galactic magnetic fields stronger than expected

July 23, 2008



LOS ALAMOS, New Mexico, July 23, 2008—Mining the far reaches of the universe for clues about its past, a team of scientists including Philipp Kronberg of Los Alamos National Laboratory has proposed that magnetic fields of ancient galaxies like ours were just as strong as those existing today, prompting a rethinking of how our galaxy and others may have formed.

With powerful telescopes and sophisticated measurements, the team probed back in time to see the ancient universe as it existed some 8 to 9 billion years ago. Their research was published in the July 17 edition of Nature.

Until now, a prevailing view in the astrophysical community has been that galactic magnetic fields gradually increased over cosmic time up to their present strengths and that in the nascent universe, magnetic fields were initially very weak. Astrophysicists explain this gradual growth of magnetism over time with the large-scale “galactic dynamo” model.

The letter in the current issue of Nature extends a parallel, larger study by Kronberg et al. of early magnetic fields from the March 2008 edition of The Astrophysical Journal. That study, whose contributors also included LANL colleagues David Higdon and Margaret Short, relied mostly on Faraday rotation measures (RM) taken at radio wavelengths, beyond what is visible to the human eye.

By measuring how far the radio waves were pulled toward the red end of the spectrum —known as “redshift”—Kronberg and his colleagues homed in on the location of magnetic fields in the distant universe.

What allowed the team to take a more detailed look at the ancient universe in this Nature letter was the addition of high-resolution optical spectra by Martin Bernet, Francesco Miniati, and Simon Lilly at the ETH Zürich (the Swiss Federal Institute of Technology) from the European Southern Observatory’s 8-meter telescope, located in Chile’s Atacama Desert. Their measurements at optical wavelengths of more than 70 quasars were combined with the RM data Kronberg has been collecting for more than 25 years – data based on accurate radio RM measurements from several of the world’s most powerful radio telescopes, including the Very Large Array near Soccoro, New Mexico, and the 100-meter dish in Effelsberg, Germany.

“It was thought that, looking back in the past, earlier galaxies would not have generated much magnetic field,” Kronberg said. “The results of this study show that the magnetic fields within Milky Way-like galaxies have been every bit as strong over the last two-thirds of the Universe’s age as they are now—and possibly even stronger then.”

Serving as a looking glass into the past, the powerful telescope at the European Southern Observatory, adding to the radio RM data, allowed the scientists to make observations of high magnetic fields between 8 billion and 9 billion years ago for 70 intervening galaxies whose faint optical absorption spectra revealed them as “normal” galaxies. That means that several billion years before the existence of our own sun, and within only a few billion years of the Big Bang, ancient galaxies were exerting the tug of these strong magnetic fields.

This research suggests that the magnetic fields in galaxies did not arise due to a slow, large-scale dynamo effect, which would have taken 5 billion to 10 billion years to reach their current measured levels. “There must be some other explanation for a much quicker and earlier amplification of galactic magnetic fields,” Kronberg said. “From the time when the first stars and galaxies formed, their magnetic fields have probably have been amplified by very fast dynamos. One good possibility is that it happened in the explosive outflows that were driven by supernovae, and possibly even black holes in the very earliest generations of galaxies.”

This realization brings a new focus on the broader question of how galaxies form. Instead of the commonly held view that magnetic fields have little relevance to the genesis of new galaxies, it now appears that they are indeed important players. If so, strong magnetic fields a long time ago are one of the essential ingredients that explain the very existence of our galaxy and others like it.